ENGINEERING HERITAGE AUSTRALIA

Nomination of Mount Stromlo Observatory for recognition under The Engineering Heritage Recognition Program

Photo Keith Baker 2013

January 2018

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Executive Summary

Astronomical observation and research has been conducted at Mount Stromlo from before the foundation of Canberra as the Australian National Capital. A formal observatory has flourished on the site since 1924, overcoming light pollution by establishing a major outstation with international cooperation and overcoming bushfire devastation to rebuild on its strengths. Over time the Mount Stromlo Observatory has evolved from solar observation through optical munitions manufacture to be the centre of optical stellar research in Australia and a world figure in astrophysics and associated instrumentation. By developing its capability in instrumentation coupled with world class testing facilities, it has become a major partner in the developing Australian space industry, and a designer and supplier of components for the world's largest optical telescopes while continuing as a leading research institution.

A key to its success in astronomy and astrophysics has been the team effort between astronomers and their support and technical staff, initially in the workshops, needed for the functioning of the local observatory, but developing over time as a synergy between astronomers, engineers and instrument technicians in continually expanding what was possible in research.

Heritage studies have been undertaken to record and assess the history of scientific achievement, the architecture, telescopes and the physical landscape of Mount Stromlo, and books have been written about the astronomers and administrators and their achievements. Although the narratives and heritage interpretive material have acknowledged the role of engineers and technical staff, there has not been a study specifically of Stromlo's engineering heritage. Yet the significance of the engineering is hollow without the significance of the astronomy and astrophysics, while the astrophysical achievement would have been impeded without the engineering team.

The nomination of Mount Stromlo Observatory for recognition under the Engineering Heritage Recognition Program therefore draws on the existing heritage studies, books, oral histories and web based information to underline the engineering role without trying to separate the engineers from the teams in which they worked other than to highlight their essential contribution.

And while the nomination is for engineering heritage, the present and future work of engineers in the Advanced Instrumentation and Technology Centre (AITC) is equally remarkable and some understanding of it is necessary to give a complete story. An outline of the history and current work of the AITC is therefore appended to the nomination document.

Some of the most significant engineering work from a physical perspective was undertaken in the observatory workshops, but as they were devastated by the 2003 bushfire and the building subsequently demolished, a section of the photographic record attempts to record that part of Mount Stromlo's engineering heritage.

1 Introduction

The Mount Stromlo Observatory is one of the oldest institutions in the ACT. It was established (as the Commonwealth Solar Observatory) in 1924, although astronomical observations had been carried out on the mountain as early as 1911. Its original interests lay in solar and atmospheric physics. During World War II, the Observatory served as an optical munitions establishment; and, after the war, it developed new research directions in stellar and galactic astronomy, with a change of name to the Commonwealth Observatory. The site was finally renamed Mount Stromlo Observatory following its amalgamation with ANU in 1957.

The Mount Stromlo Observatory complex is a functioning institution and, in association with the Siding Spring Observatory in Coonabarabran, is known as the Research School of Astronomy and Astrophysics, as part of the College of Sciences at the Australian National University. The main research interest is in stellar and extra galactic astrophysics, in particular, the structure and evolution of stars and galaxies, the origin and development of the Universe as a whole, and the physics of the material between stars[1].

Mount Stromlo Observatory is renowned internationally for its scientific achievement and is historically important for its place in the development of the National Capital. The scientific achievement has always been through multidisciplinary teams, a fact readily acknowledged by the Observatory and university staff.

This can be best illustrated by a quote from the Mt Stromlo Heritage Trail[2].

> ***One Stop Shop:*** *One of the most unique aspects of the Mt Stromlo Observatory was its capacity as a fully integrated workplace. While the main purpose of work on site was astronomy, all supporting infrastructure was on site to enable the research, development, design and manufacture of all the required instrumentation, optics and electronics.*
>
> *While it is common for the astronomers themselves to be acclaimed for their work, it must not be forgotten that the engineers, technicians, mechanics and assistants in the workshops were the key driving force behind the technology and developments which enabled many of the most famous astronomical discoveries. …The Engineering and Technical staff worked closely with the astronomers and researchers - innovating and creating instrumentation to enhance the observing capacity of the existing telescopes. They were also involved in the development of exceptionally complex projects and commissions, building whole instruments from the ground up. …The workshop complex … was completely destroyed in the 2003 firestorm. After taking up temporary lodgings on the ANU Acton Campus - the workshops were replaced by the new Advanced Instrumentation and Technology Centre.*

Over time the balance has shifted at Mount Stromlo from on-site astronomy to on-site technology, particularly since the 2003 bushfire, with astronomical observation moving to the prime observing site at Siding Spring. The new facilities and new research and engineering capacity at the Advanced Instrumentation and Technology Centre (AITC) enable the design and manufacture of key instruments and adaptive optic systems at Mount Stromlo for some of the world's largest telescopes, including the Giant Magellan Telescope, being assembled in Chile.

[1] Tanner 2004 Executive Summary
[2] Mount Stromlo Observatory Heritage Trail, ANU 2014, p20 One Stop Shop

2 Nomination Letter

Learned Society Advisor
Engineering Heritage Australia
Engineers Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Name of work: **Mount Stromlo Observatory**

The above-mentioned work is nominated to be awarded an Engineering Heritage National Marker.

The Mount Stromlo Observatory is **located as follows:**

Research School of Astronomy & Astrophysics
Mount Stromlo Observatory
Cotter Road
Weston Creek ACT 2611
AUSTRALIA

Grid reference of the Observatory Visitors Centre is:

35.32087^{o} south, 149.0007^{o} east.

Owner:

The Australian National University
Acton ACT 2601
AUSTRALIA

The owner has been advised of this nomination and a letter of agreement is to be available.

Access to site: The site is open to the public.

The Nominating Body for this nomination is Engineering Heritage Canberra

Phil Willis
Chair
Engineering Heritage Canberra

January 2018

3 Heritage Assessment

3.1 Basic Data

Other/Former Names:

Commonwealth Solar Observatory

Commonwealth Observatory

Location: Approximately 40ha, on the summit of Mount Stromlo, 15km west of Canberra, comprising that part of Block 38, Stromlo, bounded on the north and east by the block boundary and on the west and south by 745m above sea level.

Address: Mount Stromlo Road, Weston Creek, Australian Capital Territory 2611

State/Territory: ACT

Local Govt. Area: Stromlo

Owner: Australian National University

Current Use: headquarters of The Australian National University's (ANU) Research School of Astronomy and Astrophysics (RSAA).

Former Use: Solar observatory; Optical Munitions Factory

Designer: Federal Capital Commission for the initial structures (involvement of JS Murdoch and HM Rolland), various ANU architects, engineers, astronomers for other structures.

Maker/Builder: Various

Year Started: 1911 for the site with Oddie Telescope Dome, 1924 for Solar Observatory

Year Completed: Ongoing

Physical Description: Mount Stromlo Observatory Precinct, an optical astronomical research complex arranged across the ridge of a mountain, is a significant cultural landscape. Despite serious damage by the January 2003 bushfire, significant elements continuing to contribute to the heritage values of the place include the standing and remnant structures of the telescope dome buildings, the administration buildings, housing, gardens, workshop, the Duffield grave, utility structures, remaining landscape features, and the layout pattern of the complex[3].

Physical Condition: The precinct is well maintained as an operational research facility of the ANU. Following bushfire damage in 2003 the Administration Building has been fully restored (2007), the Director's Residence has been partially restored and interpreted (2015), and the Visitor's Centre has been refurbished (2016). The workshops have been replaced in a different location on the site by the Advanced Instrumentation & Technology Centre, and while the remnant structures of the destroyed research telescopes remain, in some, new telescopes have been installed for community outreach. In 2006, the first phase of construction was completed on the Advanced Instrumentation Technology Centre (AITC) which continues the design and manufacturing of astronomical instruments and testing of space equipment.

Modifications and Dates: After the 2003 bushfire, the research observation function was primarily transferred to Siding Spring Observatory near Coonabarabran NSW which had operated in parallel with Mount Stromlo since 1965. The only operational telescopes at Mount Stromlo are for community outreach to school and amateur astronomy groups, and a satellite laser ranging telescope operated by Electro-Optic Systems (EOS).

[3] Commonwealth Listed Place ID 105309, 2004

3.2 History

3.2.1 The Oddie Telescope Trial: There was early interest among the astronomy fraternity in Melbourne in establishing a solar observatory in Canberra. In February 1910 the Commonwealth government invited Pietro Baracchi, the Victorian Government Astronomer, and a party of four to the Canberra area to select a suitable site for an astronomical observatory[4]. With a telescope donated by James Oddie, Baracchi established a small observatory on Mount Stromlo in May 1911.

Within months of the proclamation of the Federal Capital Territory, astronomers from Melbourne had installed the 9-inch Oddie Refractor on the summit of Stromlo in order to site-test the mountain.

Baracchi regularly visited the site until 1913 when he reported that it 'fulfilled the most essential requirements for any class of delicate astronomical work'.

The Oddie Dome was among the first Federal buildings to be constructed in the ACT. It was designed and constructed by the Department of Home Affairs.

Astronomers later used the telescope to take spectra of southern stars, gathering information on their age, size and chemical composition; measure the orbits of binary stars; and search for remnants of supernovae in the Milky Way[5].

3.2.2 The Solar Observatory: Despite lobbying since around 1905, after World War 1 the campaign to create a national observatory was taken up again. Astronomer Walter Geoffrey Duffield was the main driving force in efforts to fill the latitude gap between the USA and India that would allow the Sun to be kept under constant observation. The Commonwealth Government gave final approval in 1923, and Duffield was appointed as the foundation Director of the new Commonwealth Solar Observatory in January 1924.

The building was designed to become the focal point, the administrative centre and the social heart of the Observatory. The building included two octagonal towers. The one at the eastern end was to carry the heliostat or sun telescope and one at the western end was for a conventional telescope (occupied by the Farnham telescope). The main building was constructed between 1924 and 1926. Work on the solar laboratories, including a long tunnel to house a spectrograph, took another 2 years to complete due to the blasting needed to excavate the basement and tunnel. During this period the Observatory was based in a wing of the Hotel Canberra (now the Hyatt).

The Heliostat was the main instrument of the Commonwealth Solar Observatory from 1931 to 1946. It was housed in a small dome above a vertical tower, which led to the solar laboratory in the basement. The Heliostat used two flat mirrors inside the dome to track the Sun and pass its light down the tower through a 12 inch lens. At the bottom of the tower, the light beam was reflected by another flat mirror to focus in one of the measuring instruments. The main instrument was a 3-prism spectrograph, regarded as one of the best in the world. This instrument was used to produce the Atlas of the Solar Spectrum which became the prime reference in the field of solar research for many years. Research was also carried out on the interaction between solar flares, sunspots and their effects on the Earth, particularly the upper atmosphere.

[4] Australian Dictionary of Biography, Baracchi, Pietro
[5] Telescopes of Mt Stromlo » The Oddie Refractor

3.2.3 Wartime Precision Manufacturing: The Second World War dramatically changed the role of the observatory[6]. The Commonwealth Solar Observatory operated as an Optical Munitions Factory, designing and manufacturing gun-sights and other equipment to aid the war effort. The Observatory swelled in size with a number of new workshops being constructed, and the staff numbers grew from 10 to 70. Mount Stromlo was the only Optical Munitions Factory in Australia equipped with the expertise and facilities to both design and manufacture munitions. Many of the new engineers were German Jews, released from a prisoner-of-war camp under the care of Director Richard Woolley.

The Observatory also acquired responsibility for the Commonwealth Time Service in 1944 and this responsibility remained until 1968.

3.2.4 Transition to Stellar Astronomy: While the main focus of the observatory in the early years was on the study of the sun, parallel work was undertaken on observation of the stars. The 6 inch Farnham Telescope[7] was installed in 1928 in the dome on the west wing of the building. Because of its small size, the Farnham had only limited use, but some of the earliest spectroscopic classification of southern stars was done with it and in the 1940s it was used to investigate variable stars.

A 30 inch Reynolds Reflector telescope was donated to the observatory in 1924 and was erected between 1927 and 1929 in a separate dome near the Solar Observatory building. It was the first reflecting telescope at Mt Stromlo and until the 1950s it was the largest operational telescope in the southern hemisphere. During the 1940s the Reynolds reflector was used for some of the first detailed surveys of southern stellar types, and in the 1950s to study stars in the Magellanic Cloud galaxies[8].

After the Second World War the research efforts of the Observatory changed from solar to stellar astronomy and the Heliostat gradually fell into disuse.

3.2.5 Big Stellar Telescopes[9]: The Observatory acquired the Great Melbourne Telescope in 1944 in pieces. The dome to house the Great Melbourne 50 inch Telescope was built and the instrument installed in the following decade.

Other telescopes were added through collaborative arrangements, government funding and self-help within the establishment at Mount Stromlo.

The 26-inch Yale-Columbia Telescope[10] was made operational on the site in 1955. It began operation in Johannesburg in 1925, as Yale University's Southern Station. Columbia University joined the telescope's research program in 1943, but increased light pollution forced the American universities to look for an alternate location. By invitation, the telescope moved to Mt Stromlo and recommenced operation as a foreign station for US astronomers. The universities donated the telescope to Mount Stromlo in 1963.

In 1955 Stromlo's largest telescope commenced operation, the 74-inch reflector built by Grubb Parsons in the UK. As the site's largest and most advanced telescope, it was the Observatory's primary research instrument throughout its lifetime.

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[6] Mt Stromlo Heritage Trail » Timeline of Mt Stromlo, See also http://rsaa.anu.edu.au/observatories/telescopes
[7] Telescopes of Mt Stromlo » Farnham Telescope
[8] Telescopes of Mt Stromlo » Reynolds Reflector
[9] Mt Stromlo Heritage Trail » Timeline of Mt Stromlo
[10] Telescopes of Mt Stromlo » Yale-Columbia Refractor

In conjunction with the University of Uppsala in Sweden, the Uppsala Schmidt telescope was erected at Mt Stromlo in 1955, (but later relocated to Siding Spring).

Around this time The Australian National University assumed control of the Observatory from the Department of the Interior and the name was formally changed to Mount Stromlo Observatory in 1957.

The various telescopes conducted different aspects of research[11]. The Oddie did the first measurement of brightness, colour and spectral classification of southern stars. The Farnham was mainly used to test instruments or used as a guide telescope for wide angle cameras. The Heliostat was used for solar observations, and the lens is now used in the Duffield heliostat in the visitor centre. The Great Melbourne telescope was adapted to search for dark matter. The Reynolds Telescope was used for surveys of southern stars and galaxies. The Schmidt telescope in the Uppsala Dome was used for surveys of the Southern Milky Way and Magellanic Clouds. The Yale Columbia telescope surveyed the distribution of stars and their motions and provided NASA with orbits for the moons of Saturn. The 74 inch Telescope was used to track the life cycles of stars.

From 1957 Mount Stromlo astronomers began looking for a better observing site free from city light pollution and by 1962 Siding Spring Mountain near Coonabarabran was selected for a new field station and officially opened in 1965. After the jointly funded Anglo-Australian Telescope was constructed at Siding Spring was opened in 1974, with significant scientific and engineering input from Mount Stromlo staff, Uppsala Schmidt telescope was relocated in 1981, and a new 2.3 m telescope was designed and built at Mount Stromlo to be opened at Siding Spring in 1984.The project received and Engineering Excellence Award the following year.

3.2.6 Laser Ranging and space debris tracking: A Satellite Laser Ranging (SLR) Observatory was installed on Mt Stromlo in 1998 adjacent to the Observatory. It was built and operated by Electro Optic Systems Pty Ltd for Geoscience Australia, in collaboration with the Mount Stromlo Observatory[12]. The initial facility was destroyed by fire in 2003, but the redevelopment that was already in progress enabled a new facility to be opened in 2004. The shared research centre incorporates a number of functions including the tracking of space debris to avoid collision with satellites, the Geoscience Australia laser ranging facility, a telescope test facility and an atmospheric monitoring facility. Laser ranging is used by Geoscience Australia as part of a world-wide network of stations to determine the precise orbit of reference satellites and thereby to monitor changes in the position of the stations on the Earth's surface.

3.2.7 Astronomical Achievements: The first notable research achievement was with the Heliostat and spectrograph were used by Clabon Allen in the 1930s to produce an Atlas of the Solar Spectrum. By analysing the intensity of the dark lines that cross the Sun's spectrum, Allen made a significant contribution to the understanding of the elements that make up the Sun' atmosphere and developed a Solar Atlas which gained the Observatory international recognition and became an important reference to solar researchers for many years.

In the 1950s astronomer Ben Gascoigne used the Reynolds telescope to study stars in the Magellanic Cloud galaxies, leading to the discovery that the universe was twice the size and age than previously thought. This work was supported by Gerald Kron, a US engineer turned astronomer who was expert in constructing instruments for astronomical purposes, especially photoelectric photometric instruments[13].

[11] Australian Heritage Database Mount Stromlo Observatory Precinct –History
[12] http://rsaa.anu.edu.au/research/highlights/eos-we're-working-business-and-satellite-technology
[13] Bhat, Sutherland & Butcher p85

In 1957, Stromlo research engineer Kurt Gottlieb captured the first Western photograph of the Soviet Union's *Sputnik 1*, the first artificial satellite. The image graced the cover of the New York Times.

In 1984 Stromlo scientists Mike Bessell and John Norris discover the oldest star, a record which stood for over 20 years. The same team reclaimed this title in 2014.

Stromlo astronomer Ken Freeman was one of the first people to suggest the presence of an invisible mass in the Universe. In 1970 he 'weighed' some spiral galaxies by calculating the mass of all the visible objects, revealing that there was not enough visible mass to create enough gravity to hold the galaxy together. The missing mass was called 'dark matter', which we now know makes up about 25% of the Universe. In 1992 Mt Stromlo embarked on the MACHO project (Massive Astronomical Compact Halo Objects), in an attempt to identify the source of the mysterious 'dark matter'. The project ruled out MACHOs as an adequate explanation, and also led to the first discoveries of exoplanets (planets beyond our own solar system).

From 1994, Mount Stromlo Director Jeremy Mould led the team that used the Hubble Space Telescope to accurately determine the Hubble Constant (the rate of the Universe's expansion). From this finding, the age of the Universe was recalculated to be about 13 billion years old.

In 1998, following observations of supernovae using the Reynolds Reflector, Mt Stromlo researcher Brian Schmidt (along with two other astronomers from the United States) published evidence that the Universe is expanding at an accelerating rate. This observation led to the team's discovery of 'dark energy', which accounts for about 70% of the Universe. Professor Schmidt was named a joint winner of the 2011 Nobel physics prize for his ground-breaking research on supernovae and the expansion of the universe.

3.2.8 Destruction: In 2003 a bushfire which started in NSW spread to the Cotter catchment and developed into a firestorm which devastated Mount Stromlo and Canberra suburbs, most notably Duffy and other Weston Creek and Tuggeranong suburbs close to Mount Stromlo. The firestorm severely damaged the Mount Stromlo observatory, its telescopes, workshops and associated laser ranging facility.

The firestorm hit Mount Stromlo on 18 January 2003 and the report of 20 January in the Sydney Morning Herald encapsulated the story of devastation:

> *A third of Australia's world-leading astronomy program was wiped out when the Canberra bushfires gutted the Mount Stromlo Observatory[14]. The flames destroyed five telescopes, the workshop, eight staff homes and the main dome, causing more than $20million in damage. The historic 1.3 metre-diameter Great Melbourne Telescope, built in 1868 and upgraded in 1992 to become one of the most sophisticated in Australia, was lost, as was a larger, 1.9-metre instrument. The Great Melbourne had been used in 1993 for world leading research into dark matter.*

It was the belief at the time of Professor Brian Schmidt that the inferno had devastated Australia's hopes of becoming a world leader in the building of advanced technology used in the world's biggest telescopes. A $5million imaging spectrograph had been destroyed in Mount Stromlo's workshop that was almost ready to be installed in Hawaii's gigantic Gemini Observatory, one of just two 8.1-metre-diameter telescopes in the world. A month earlier Mount Stromlo had won an international competition to build a second instrument, a $6.3million camera to be fitted to the second Gemini telescope, in Chile.

Mount Stromlo had been damaged in earlier bushfires (notably in 1952), but to a much lesser extent. After it came under threat in 2001 the university established a project to reduce the risk[15]. An external fire engineering study recommended clearing vegetation from the western

[14] Richard Macey and Michael Bradley, Sydney Morning Herald 20 January 2003
[15] http://facilities.anu.edu.au/index.php?pid=132

side of the mountain, installing external sprinklers and improving the water pressure. Much of this work had been undertaken by January 2003, but with the severity of the fire front it was of limited benefit. The Visitors Centre was saved as there was little fuel to feed the fire, and the Duffield and Woolley Buildings were saved by internal sprinklers. But more than a dozen buildings, five telescopes and residences were left in ruins. Restoration work has been carried out on the historic administration building and others repaired or replaced, but damaged telescopes have not generally been replaced on site, with the alternative site of Siding Spring near Coonabarabran being a better technical option.

3.2.9 On-site Research and Off-site Observation: The Observatory had just refitted the 50 inch Great Melbourne Telescope as an automated sky survey instrument when the bushfire swept through the area. Although the telescope's destruction was a major research setback, it also presented an opportunity to design a better replacement survey telescope known as SkyMapper[16]. Growing light pollution in Canberra and improvements in communications technologies led to the decision to site SkyMapper at the Siding Spring Observatory. Skymapper is state-of-the-art both in terms of the 1.35m diameter optics and the 268 megapixel detector designed and built at the ANU. SkyMapper's main task is to conduct the first ever systematic survey of the entire southern sky to produce a detailed digital map. Data is transmitted to the ANU supercomputer facility for processing. The telescope is fully automated, with the astronomers working from the Mount Stromlo Observatory.

3.2.10 Astronomical instrumentation: The destroyed workshop at Mount Stromlo was replaced temporarily by shared facilities elsewhere and the first stage of the new Advanced Instrumentation and Technology Centre[17] was completed in 2006. It included optics workshops and a large assembly hall in a world-class facility for developing and testing astronomical instrumentation, small satellites, and space payloads.

The facilities in the new centre have enabled many technical projects to be completed, including a new spectrograph for the 2.3m telescope at Siding Spring, a second instrument for the Gemini Observatory telescope in Chile, and the wide-field imaging camera for the Siding Springs SkyMapper telescope.

More recent facilities include a computer-controlled "shaker" capable of exerting acceleration forces of several tons on instruments under test before they are launched into orbit, or ensuring telescope parts can withstand the rigors of land transport. Another new facility is a thermal vacuum chamber measuring three metres in diameter and four metres long that can simulate the airless environment of space and test performance at extreme temperatures. There are also a number of clean rooms, workshops and a large screened chamber capable of blocking out background radio noise. The test facility is creating new opportunities for Australian science and industry to engage more strongly in the rapidly expanding field of space exploration.

Australia's partnership in the Giant Magellan Telescope currently being built in the Andes - mountains of Chile will guarantee ANU astronomers a 5% share in what will be the largest and most powerful telescope in the world. The ANU contribution to the telescope design and future instrumentation projects will take place at the Advanced Instrumentation and Technology Centre. A major aspect of the ANU's current work involves adaptive optics[18], a technology that is essential to the success of high-resolution observations with the next generation of large ground-based telescopes. Adaptive optics systems correct for the distorting effects of turbulence in the atmosphere, using deformable mirrors that precisely cancel out the wavefront distortion enabling a telescope to resolve images of faint distant objects much more clearly. Because the atmospheric structure changes thousands of times each second, it would be impossible to deform the massive primary mirrors of the Giant Magellan Telescope quickly enough to compensate. So, it will be the adaptive secondary

[16] http://sciencewise.anu.edu.au/articles/skymapper
[17] http://rsaa.anu.edu.au/research/highlights/things-are-taking-mount-stromlo-observatory
[18] http://sciencewise.anu.edu.au/articles/jitters

mirrors that will accomplish this task with 672 individual actuators to precisely deform the mirror surfaces at very high speeds.

3.2.11 Engineering expertise: The equipment needed to make precise astronomical observations is highly specialised and, as a result, much of it is specifically designed for individual applications. The Research School of Astronomy and Astrophysics has a long history of technical research and development, and is equipped with specialised engineering facilities for astronomical instrumentation. These include a mechanical engineering design office and sophisticated mechanical workshop, an electronic design and manufacturing group, optics design and manufacturing laboratories, and a software group that develops and implements control systems for telescopes, instruments, and data processing.

Much of the early impetus for ongoing development of engineering expertise at Mount Stromlo can be credited to Alexander Rodgers, the sixth Director of the Observatory from 1987-1992. His career at Mt Stromlo had started 32 years earlier. In 1954, Rodgers won a scholarship to complete his PhD at the ANU. Rodgers ended up staying and he spent his entire astronomy career at the Mt Stromlo Observatory. His passion for engineering was a key influence on his Directorship. He argued very strongly that Stromlo's engineering capability was a vital part of its identity and its role in the future. Rodgers' ensured that Mt Stromlo maintained its scientific leadership through his focus on developing new instrumentation, such as a custom-built spectrophotometer and photon-counting arrays.

Workshop staff have reflected on the innovation that happened daily within the workshops - noting that the expertise of the staff allowed old equipment to be innovated, modernised and made useful long after its original purpose was superseded. They were also involved in the development of exceptionally complex projects and commissions, building whole instruments from the ground up. Such work included the construction of the highly advanced 2.3m telescope at Siding Spring Observatory and the Near-Infrared Integral Field Spectrograph which was being constructed for the Gemini Telescope in Hawaii, and was tragically lost in the 2003 fire just days after its completion.

The earliest engineering staff member was Kurt Gottlieb, who was recruited in 1940 as a refugee by Richard Woolley soon after he became Observatory Director. Woolley committee the observatory to the war effort and was desperate for skilled staff in optics and mechanics. Kurt Gottlieb, from an Austrian middle class Jewish family, had escaped Nazi anti-Semitism. However his engineering degree was not recognised in Australia and he enrolled in a technical college draftsman's course, where he came under notice from Woolley who offered him employment at Mount Stromlo. He worked as a mechanical designer and became research engineer during war[19]. When his academic qualifications in mechanical engineering were recognised, Gottlieb was made a Research Fellow at Mount Stromlo Observatory and was also put in charge of the workshops[20]. Among many other achievements he designed an electron multiplier photometer with Cla Allen for the Reynolds telescope in 1947[21], and in 1957 he managed to secure the first photo of Sputnik taken in the west as it passed over Mount Stromlo. The associated publicity and cold war concerns were used by Director Bart Bok to gain political and funding support for the observatory[22].

Another well-known Stromlo engineering identity is Hermann Wehner, the longest serving and extremely loyal engineer who joined the staff at Mount Stromlo in 1952[23] He officially retired in 1980, after which he was re-employed as a casual engineer, was called in to work on various projects and finally worked as a volunteer guide at the Visitors Centre.

[19] Stromlo, an Australian Observatory, Tom Frame & Don Faulkner, 2003, p84
[20] http://www.asap.unimelb.edu.au/bsparcs/exhib/omp/people/gottlieb.htm
[21] Frame & Faulkner p100
[22] Mt Stromlo Observatory, From Bush Observatory to the Nobel Prize, R Bhat, R Sutherland & H Butcher,2013, p110
[23] Oral History recording https://openresearch-repository.anu.edu.au/handle/1885/117119

After training as an instrument maker, working at the solar observatory at Gőttingen University and undertaking formal engineering studies in Munich from 1949-52, Wehner was sponsored by the Mt Stromlo Director, Professor Woolley, to immigrate to Australia. His first major task, with Kurt Gottlieb (by then head of engineering design) was to rebuild the 1868 Great Melbourne Telescope which had been bought in 1944 when the Melbourne Observatory closed, but was still in pieces. Hermann Wehner worked on it for a number of years, including installing it within its dome. He also worked on the 74 inch Grubb Parsons telescope commissioned at Mount Stromlo in 1955 before embarking on more demanding work to establish the Siding Spring Observatory. The task over the period 1967-1975 involved providing technical advice during the planning negotiations for a joint venture telescope with the British government and subsequently project managing the construction and Australian adaptation of its realisation as the 3.9 metre AngloAustralian telescope at Siding Spring. Another telescope he was closely involved with was the 2.3 metre Advanced Technology Telescope, built in 1976-7 for the Siding Spring Observatory. Designing and building this innovative telescope required a team of four engineers which he led.

In his retirement role as a tour guide Wehner would focus on the technology and science aspects, explaining what the telescopes represented and their capabilities. On the day of the 2003 fires, the 79 year old was working at the Visitors Centre, taking a tour to see the 74" telescope in its dome, where he had recently installed a multi-focus viewer capacity. One visitor on the tour asked how long the telescope had been there, to which he replied that it had been there for 50 years and it was good for another 50. This was on the same day the telescope and dome had been destroyed by the fire.

Many younger engineers worked with Wehner, shared in development projects and continued on his work, including optical design engineer Gabe Bloxham and mechanical design engineer John Hart[24]. They commenced at Mount Stromlo about 20 years later and are still key staff members. A career collaborative highlight was in the 1980s when the 2.3 m Advanced Technology Telescope was initiated and designed at Mount Stromlo and built in Australia (more than 95 % local content), particularly by the engineering and technical staff in the Observatory workshop. Computer control allowed a change in design from the previous heavy equatorial axis style to alt azimuth arrangement of tracking in two directions, with mounting in a building that rotated and could therefore be made more compact. John Hart was principally responsible for the telescope design, Hermann Wehner for the rotating building and Gary Hovey for the control systems. Opened in 1984 at Siding Spring, the project won the IEAust Canberra Division Engineering Excellence Award the following year.

After more than 20 years of valuable service, the 2.3 m telescope was becoming less reliable with scarcity of spare parts, particularly for the drive system electronics, but it needed to continue in service for several years until the SkyMapper Southern Sky Survey could be completed. The team that built the telescope was reassembled, led by Hermann Wehner who was again brought out of retirement, to refurbish the telescope with minimal budget but with great dedication[25].

In contrast to the engineering and technology staff levels when Mount Stromlo concentrated on being an observatory, the Research School of Astronomy and Astrophysics, including the Advanced Instrumentation and Technology Centre, now employs 57 astronomers with 17 engineers, seven instrumentation scientists and five technical managers among the support staff. The engineers who make up a significant component of the team are classified as opto-mechanical, electronic and software engineers[26].

[24] Interviewed jointly for the ANU oral history program https://openresearch-repository.anu.edu.au/handle/1885/117112
[25] Bhat, Sutherland & Butcher p 271
[26] http://rsaa.anu.edu.au/people?title=&tid=34&=Search

Since the 2003 fire, the site has been rebuilt with a commitment to supporting world-class Australian research through the development of the next generation of instrumentation for astronomy and space science. This includes increasing national and international collaboration, growing capability for the manufacture and testing of advanced instrumentation, supporting stronger collaboration with industry, and training our future scientists and engineers.

The Advanced Instrumentation and Technology Centre was established as a national facility for the assembly, integration and testing of precision instrumentation and small spacecraft. The Centre is designing and manufacturing key instruments and adaptive optic systems for some of the world's largest telescopes including the Giant Magellan Telescope in Chile, South America. It is also using adaptive optics to help track and de-orbit space debris through the Space Environment Research Centre.

New facilities and new research and engineering capacity ensure that Mt Stromlo Observatory continues to grow as a world-class facility, representative of the highest levels of technology and innovation internationally.

3.3 Heritage Listings

For each heritage listing:

Name: Register of the National Estate (RNE) (Non-statutory archive)

Title: Mount Stromlo Observatory Precinct

Number: 13353

Date: Registered 11/8/1987

The RNE ceased to have statutory effect in February 2012 and the RNE listing does not provide direct legal protection or prescriptive requirements for management. The RNE is retained by the Commonwealth as an archival database of places. The RNE citation matches the CHL citation

Name: Commonwealth Heritage List (CHL)

Title: Mount Stromlo Observatory Precinct

Number: 105309

Date: Registered 22/6/2004

The site has statutory protection under the EPBC Act. The official citation determines that the Mount Stromlo Observatory Precinct meets the threshold for listing on the CHL for six of the nine Commonwealth Heritage criteria. The 2014 GML Heritage Management Plan reassesses the heritage values against the Commonwealth Heritage List criteria.

Name: National Trust of Australia ACT Registration of Classified Places 1979-2004

Title: Mount Stromlo Observatory

Date: Registered 24/11/1980

The National Trust (ACT) no longer classifies places, but nominates them to the ACT Heritage Register which legally recognises and protects significant heritage places within the Australian Capital Territory. However the Mount Stromlo Observatory Precinct was rejected for provisional listing by the ACT Heritage Council because the site is located on National Land, under the control of the Commonwealth.

4 Assessment of Significance

As noted above, the 2014 GML Heritage Management Plan carried out a detailed reassessment of the significance of the Mount Stromlo Observatory against the Commonwealth Heritage List criteria. Where relevant to this nomination, the assessment by GML has been used, with editing as considered appropriate to the narrower focus being applied in this nomination for the Engineering Heritage Recognition Program.

4.1 Historical Significance: The Mount Stromlo Observatory Precinct is highly significant to the course of Australia's cultural history. It is the earliest example of Commonwealth scientific endeavour located in Canberra and demonstrates the role that the Commonwealth has played in scientific research from the period shortly after Federation. The creation of the Australian Capital Territory provided a focus as the location for such activity and the Observatory is associated with the early period of development of the National Capital. The Observatory reflects both the Commonwealth's interest in science and a vision for Canberra as the location for scientific institutions, as well as general government administration. The Mount Stromlo Observatory is one of a number of scientific buildings or complexes commenced by the Commonwealth in the Territory in the years following Federation. The Mount Stromlo Observatory Precinct is a complex landscape incorporating structures from all historic phases of development of the site; pre-1923, 1924–1938, 1939–1955, 1956–1977, 1978–2003 and 2003–Present. The Oddie Telescope Dome was constructed in 1911 to house the first telescope on site; it is one of the earliest purpose built Commonwealth buildings in the ACT, and was established to test the site for its suitability as an observatory. The Mount Stromlo Observatory Precinct is significant for its outstanding scientific research in optical astronomy and astrophysics, as well as telescope design and engineering achievements. It has retained its continuity of use since its establishment as a research institution and in the ongoing development of instrumentation. During World War II the Observatory played a vital role as an optical munitions factory contributing substantially at a scientific level to the war effort in the manufacturing of optical instruments. The expansion of the site in the 1950s with considerable telescope acquisition reflects the importance of science at that time, and is demonstrated through the remnant telescope dome buildings. The scientific research undertaken at the site has resulted in notable achievements. This includes the comprehensive photometric atlas of the solar spectrum produced by Clabon Allen, the highly acclaimed 1960s MACHO Project which focused on resolving missing mass in the universe, and the discovery of the Magellanic Stream. The 2003 construction of the modern state of the art Advanced Instrumentation Technology Centre (AITC) continues the function of the site for scientific research and the development of astronomical instrumentation for Australia and internationally.

The 2003 firestorm is a historically significant event in the history of the Mount Stromlo Observatory, which destroyed most of the buildings and workshops, research telescopes, instruments, important research and records on site, as well as the vegetation, including the surrounding pine plantation. The evidence of the ruined buildings and domes demonstrates the extent of the devastation[27].

4.2 Historic Individuals or Association (including biographies of relevant historical individuals): The place is significant for its strong association with scientists who have made a substantial contribution to astronomy and astrophysics. Notable among these was Professor Brian Schmidt who was a co-recipient of the Nobel Prize for Physics 2011 for the discovery that the universe is expanding at an accelerating rate.

The 10 directors of the Observatory since its establishment in 1924 have played vital roles in the development of the site and their contribution to astronomical science;

[27] GML p100 Revised Heritage Values Assessment Criterion (a)

- the first Observatory Director, Walter Geoffrey Duffield (January 1924-August 1929), was pivotal in the establishment of the site. Duffield studied science in Adelaide, obtained an engineering scholarship to Cambridge University and later a Doctor of Science for research in spectroscopy in Manchester, where he gained experience and influence to pursue the idea for an Australian solar observatory that he had held since 1905[28].
- the second Director, Richard Woolley (December 1939- December 1955), was selected by a panel of eminent astronomers in the UK . He On arrival in Australia he engaged with the Government in leading the Observatory devote its resources to the production of optical munitions during World War II.Wooley subsequently changed the focus of the observatory from solar to stellar astronomy and oversaw the largest telescope acquisition to the site during the 1950s, before returning to England to become Astronomer Royal.
- Bart Bok (March 1957-March 1966) was born and studied in Holland before working at Harvard on both optical and radio astronomy. He accepted an invitation an invitation from ANU as an opportunity to pursue his passion in mapping the Milky Way[29]. He advanced the development of optical astronomy in Australia and its integration with the field of radio astronomy. He was passionate about public education in the promotion of astronomy, and establishing a thriving international graduate program at Stromlo. Bok obtained funding to advance high resolution spectroscopy and digital computing at Stromlo, and established a dark sky field observatory at Siding Spring with three telescopes operated before the Anglo Australian telescope was negotiated.
- Olin Eggen (July 1966-September 1977) was born in the US and became a highly regarded academic in astrophysics in the UK and US. He had made two extended observing visits to Mount Stromlo during his early career before becoming its fourth Director. During his tenure he worked tirelessly if somewhat reclusively on research, and facilitated the construction of new instruments, including image intensifying and infrared astronomy. The Anglo–Australian Telescope was built at Siding Spring. His directorship was a period of growth for optical astronomy and by the end of his term, Australia was recognised as a major player in international astronomy[30].
- Donald Mathewson (April 1879-May1986) was the first Australian born Director, having graduated from University of Queensland and subsequently studied for his PhD at Manchester University, worked with the CSIRO Radiophysics Division, he was appointed from within the staff of Mount Stromlo. He was regarded as an entrepreneur, and while his own research work involved radio astronomy, he directed the design and construction of the Advanced Technology Telescope using Mount Stromlo scientific and engineering staff.
- Alexander Rogers (June 1987-December 1993) was also Australian born, was recruited to Mount Stromlo by Wooley in 1954 with a post graduate scholarship, spent virtually all his notable career at Stromlo and was the first Mount Stromlo graduate to be appointed Director[31]. He had always been heavily involved in the development of astronomical instruments through the Stromlo workshop and argued that Stromlo's engineering capability was a vital part of its identity and role in the future[32]. During his term new instrumentation was developed for the 2.3 m telescope and dark matter research was undertaken. Rogers advocated for a large Australian optical telescope, but no suitable site could compare with Chile or Hawaii.
- Jeremy Mould (December 1993-January 2001) had also undertaken his PhD at Mount Stromlo and after many years in a wide range of overseas observatories he returned to Stromlo as its seventh Director. He saw the future path as international collaboration in large optical telescopes since Australia would not be host to its own. The Government initially blocked such a partnership, but by supporting Australian observing time in the Gemini telescopes in Hawaii, Australia gained contracts for the design and construction of

[28] Bhat, Sutherland & Butcher p5
[29] Frame & Faulkner p136
[30] Obituary written by Ken Freeman, http://oa.anu.edu.au/obituary/eggen-olin-jeuck-343
[31] Frame & Faulkner p124
[32] Bhat, Sutherland & Butcher p188

spectrographic instruments in the Stromlo workshops. Mould was also involved in a joint Antarctic research project and established the Stromlo Visitor Centre to bring astronomy back to the public. He also led specific observations and analysis from NASA's Hubble Telescope. During his tenure Brian Schmidt joined the strong research team at Stromlo leading to his discovery that the universe expansion was accelerating.

- Penny Sackett (July 2002-May 2007) was educated in the US and had a record of research on galaxies and the search for extra solar planets. She had spent a sabbatical working at the Anglo-Australian Observatory before being encouraged to apply for the Mount Stromlo Directorship and was keen to see Australia involved in one of the giant telescope projects. It was through her initiative that Australia is now part of the Giant Magellan Telescope construction[33]. About six months into Sackett's directorship Mount Stromlo was devastated by bushfire, destroying research facilities including telescopes, library facilities, and workshops where staff had built instruments for their own and other organisations. One of the major challenges after arranging to reconstruct the NIFS order for Hawaii was to rebuild the workshops which had always been an integral part of Mount Stromlo. A modern Advanced Instrument Technology Centre was built in Stages. Sackett responsible for the building of Stage 1 which was opened in in 2006 with laboratories large enough to handle production and testing of instruments and subsystems for the Giant Magellan Telescope[34].
- Harvey Butcher (September 2007-January 2013) was an American who had undertaken his PhD at Stromlo and returned more than three decades later to take up the directorship when Penny Sackett became Australia's Chief Scientist. With his long experience in technology management, Harvy Butcher revitalised the engineering group at Mount Stromlo, and vigorously pursued the opportunities for instrumentation for the Giant Magellan Telescope[35]. Butcher continued two internationally important projects begun during Sacket's years, the wide field spectrograph and Schmidt's Skymapper to produce a map of the southern skies.
- Matthew Colless, graduated from University of Sydney and undertook his PhD at the Institute of Astronomy at Cambridge (1988) and was based at the Mount Stromlo Observatory as a researcher from 1993 to 2004, returning as tenth Director (2013-present). He was a key member of the international team working on the 2dF Galaxy Redshift Survey, a great scientific achievement measuring the amount of dark matter in the universe[36]. His research uses large redshift surveys of galaxies to understand their evolution, the large-scale structure of the universe, and the cosmological model. Colless is also the vice chair of the Giant Magellan Telescope Organisation Board[37].

No individual engineer has been given credit in the Heritage Listings referenced, or either of the Conservation Management Plans for a significant historical role, although PT Owen was mentioned in passing in the Tanner 2004 plan[38], while giving full credit to his subordinate John Smith Murdoch as the architect for the Main Observatory Building. Engineer Col Percy Owen was Inspector-general of Works (1903-1909), Director-general of Works (from 1909 to 1924), and subsequently Chief Engineer in the Federal Capital Commission (1925 to 1929) covering the whole period of the selection of the site of Canberra, the establishment of the Oddie Telescope (1911) through to the establishment of the Solar Observatory (1924), the completion of the Main Observatory Building (1929) and the roads, electricity, water and other services associated with Mount Stromlo. While such engineering did not involve direct engagement with the astronomers who made Mount Stromlo internationally known, it was none the less important. But it was the many unnamed engineers, instrument technicians,

[33] Bhat, Sutherland & Butcher p225
[34] Bhat, Sutherland & Butcher p238
[35] Bhat, Sutherland & Butcher p253
[36] GML p104 Revised Heritage Values Assessment Criterion (h)
[37] http://www.anu.edu.au/about/governance/committees/professor-matthew-colless
[38] Tanner p49, 51

trades and associated scientific staff working in close collaboration and teamwork on site with the astronomers that made their achievements at Mount Stromlo possible.

4.3 Creative or Technical Achievement: The Mount Stromlo Observatory demonstrates a high degree of technical achievement through the continuous use of the site for astronomical observations, research and technological development. The design and manufacture of optical equipment during World War II resulted in the improvement of visual (telescopic) and communication technology that greatly enhanced operations in the field. The early telescope domes and buildings provide an understanding of the advanced technology required for optical observing. The 74inch Dome was the equal largest dome in the southern hemisphere from its construction up until 1974. As well as telescopes the site was developed with integrated 'one stop shop' workshops with engineers and technicians to design and develop equipment and instrumentation to support scientific research. This onsite technical expertise and purpose built facilities resulted in little work being contracted out, for example the design and construction of the 2.3 metre telescope and its rotating building which was designed and built at Mount Stromlo for installation at the Siding Springs Observatory. Scientific research and work undertaken at Mount Stromlo Observatory demonstrates a high level of technical achievement, including the MACHO Project and the contribution of the RSAA's research and engineering to international projects such as the Giant Magellan Telescope and the Gemini Telescopes. The advancement of technology has resulted in the need to develop purpose built and state of the art facilities at the site. The modern AITC reflects the ongoing need to accommodate the changing requirements in astronomical technology. The Mount Stromlo Observatory is recognised for significant technical achievements in the development of optical munitions during World War II, contributions to national and international scientific understanding in the field of astronomy, astrophysics and solar aspects; and it continues to be associated with many scientists who are highly respected in their field of scientific endeavour[39].

4.4 Research Potential: The overall archaeological potential of the Mount Stromlo Observatory Precinct is relatively low. Generally the creation of archaeological deposits across the site during its use is likely to have been low. Any deposits that accumulated prior to the bushfires would have been disturbed in the subsequent clean-up[40].

4.5 Social: The Mount Stromlo Observatory has significant social values to the scientific community, ANU staff and researchers, amateur astronomers and the broader Canberra community who have a strong association with the place, demonstrated by the numerous publications, social events, site functions, scientific reports, news articles, art shows and historical exhibitions. The scientists, staff and their families who lived and worked on site due to the initial remoteness and isolation of the site formed a unique community. Communal activities such as tennis, and social events held at the Director's Residence provided occasions for social interaction. The ongoing provision of accommodation in the residential precinct located on the south side of the ridge retains a sense of community life at the site. The Mount Stromlo Observatory demonstrates a community spirit established from perseverance through the adversity of fires, both in 1952 and 2003. The broader Canberra community who were affected by the 2003 fires have strong associations to the site. This is demonstrated through commemorative events and exhibitions including the Past, Present and Future display and the 10 year anniversary of the 2003 fires, held at Mount Stromlo. The donation of public funds to the establishment of Outreach Telescope Domes following the fires demonstrates the importance that the community holds in the ability to use the site for observation purposes. Public visitors to the site who experience the views, photograph the structures, partake in astronomical observing events, undertake recreational activities or visit the cafe all have a close connection to the site[41].

[39] GML p103 Revised Heritage Values Assessment Criterion (f)
[40] GML p79
[41] GML p103 Revised Heritage Values Assessment Criterion (g)

4.6 Rarity: Mount Stromlo Observatory Precinct is a rare example of an optical observatory complex in Australia[42].

The Mount Stromlo Observatory Precinct is one of two optical observatories managed by the ANU (the other being Siding Spring Observatory near Coonabarabran), and is one of several observatories established in Australia and internationally. It has continuously provided the function of astronomical observation and research in its location since 1911. The layout of the Observatory and its key buildings on a ridge, set away from light sources (initially), with its telescope domes, residences and workshop buildings set out in distinct functional precincts remains evident to this day. During the period from 1944 to 1968 the site was the home of the Commonwealth Time Service, established by Ben Gascoigne and Richard Woolley, using the transit telescope, quartz clocks to track stars passing the zenith line and setting the time for Australia. The Mount Stromlo Observatory is one of the early purpose-built Commonwealth complexes in the nation's Capital. It demonstrates the Commonwealth Government's commitment to scientific endeavour through the establishment of a self-sufficient institution with a range of functional buildings including research buildings and domes, workshops and residences[43].

4.7 Representativeness: The Mount Stromlo Observatory is representative of purpose built Commonwealth institutions established following Federation. The separate functional areas and the complex of buildings demonstrate the need for a self-sufficient site and the hierarchical division of building types (residential, scientific and administration). The Observatory is characteristic of other national and international observatories, with similar scientific and site specific facilities, functional layout, setting on a hill or ridge, and typical dome structures[44].

4.8 Integrity/Intactness: The built elements at the Mount Stromlo Observatory are in various levels of physical condition. The buildings which were not affected by the 2003 fires, were reconstructed, or are newly built are in good condition; while the structures that are heritage ruins with only minor clearing or stabilisation works are in poor condition and require structural assessments to ensure their stability and management as heritage ruins. It is important to note that deterioration in condition does not necessarily correspond to a loss of heritage value[45].

4.9 Statement of Significance: Mount Stromlo Observatory is significant for its outstanding scientific research in optical astronomy and astrophysics, as well as telescope design and engineering achievements. During World War II it played a role as an optical munitions factory. It has retained its continuity of use as a research institution since its establishment, achieving international recognition for its advancement of science in the structure and evolution of stars and galaxies, the origin and development of the Universe as a whole, and the physics of the material between stars. This has been coupled with the development, design, production and testing of world leading scientific instrumentation.

From an engineering perspective Mount Stromlo Observatory is significant as a self-contained research, development and manufacturing facility built on more than 90 years of teamwork involving astronomers and research scientists with highly skilled engineers, instrumentation scientists, technicians and trades staff. This synergistic arrangement has led not only to the world leading advances astronomy and astrophysics for which Mount Stromlo is renowned, but has also enabled outstanding advances that would not alone have been possible in Australian optics, instrumentation and software being incorporated into the world's largest optical telescope.

[42] GML p94 Commonwealth Criterion (b)
[43] GML p101 Revised Heritage Values Assessment Criterion (b)
[44] GML p102 Revised Heritage Values Assessment Criterion (d)
[45] GML p122

4.10 Area of Significance: Three way cooperation between scientific, engineering and technical staff to achieve world leading research and production.

5 Interpretation Plan

5.1 General Approach:

ANU has been exploring interpretation opportunities to provide an engaging experience for visitors and site users through targeted interpretation methods including the Interactive Heritage Trail (launched 2014); the interpretive works undertaken as part of the conservation and stabilisation of the Director's Residence; and the opening of a new Visitor Centre in 2016. The site offers a diverse range of opportunities for presenting the heritage values through an understanding of the science, research, history and development of the Observatory, as well as the devastation of the fires[46].

Date and time of ceremony: To be determined in consultation with ANU

Site of Ceremony: Expected to be on site at Mount Stromlo

The interpretation panel location: Likely to be in the Mount Stromlo Visitor Centre

5.2 Interpretation Panel:

A title and sub title if proposed: Productive Collaboration; Engineering at Mount Stromlo.

Details of the panel will be developed in consultation with the ANU Heritage Officer.

6 References:

Australian Heritage Database, *Mount Stromlo Observatory Precinct, Mt Stromlo Rd, Mt Stromlo, ACT, Australia*, Commonwealth Heritage List, Place 105309, 22/06/2004

Mount Stromlo observatory conservation management plan, Tanner Architects, 2004

The Mount Stromlo Observatory Precinct Heritage Management Plan, GML Heritage, July 2015

Mt Stromlo Heritage Trail, ANU 2014
http://msoheritagetrail.anu.edu.au/
http://msoheritagetrail.anu.edu.au/timeline
http://msoheritagetrail.anu.edu.au/telescopes

[46] GML p128

ScienceWise - Autumn 2011, *Taming the jitters: Developing the adaptive optics for the world's most powerful telescope,* http://sciencewise.anu.edu.au/articles/jitters

ANU RSAA Instrumentation http://rsaa.anu.edu.au/research/themes/instrumentation

ANU Heritage Office Oral History Recordings, *Interview with Hermann Wehner*, 18 Feb 2014 https://openresearch-repository.anu.edu.au/handle/1885/117119

Interview with Gabe Bloxman: optics specialist, and John Hart: engineer, 12 March 2014 https://openresearch-repository.anu.edu.au/handle/1885/117112

Stromlo; an Australian observatory, Tom Frame and Don Faulkner, Allen & Unwin, 2003

Mount Stromlo Observatory; from bush observatory to the Nobel Prize, Ragbir Bhathal, Ralph Sutherland and Harvey Butcher, CSIRO Publishing, 2013

ANU Mount Stromlo 2004 site interpretation brochure, formerly accessed at http://www.mso.anu.edu.au/info/documents/MSOSignage2004.pdf and referred to in *A Century of Canberra Engineering*, Keith Baker, Engineers Australia 2013, p79

7 Acknowledgments, Authorship and General Notes

7.1 Acknowledgments: The support and encouragement of Amy Jarvis, ANU Heritage Officer , Jack Dunstan, Collections Officer, and Milica Symul and Brad Tucker of The ANU Research School of Astronomy and Astrophysics is gratefully acknowledged.

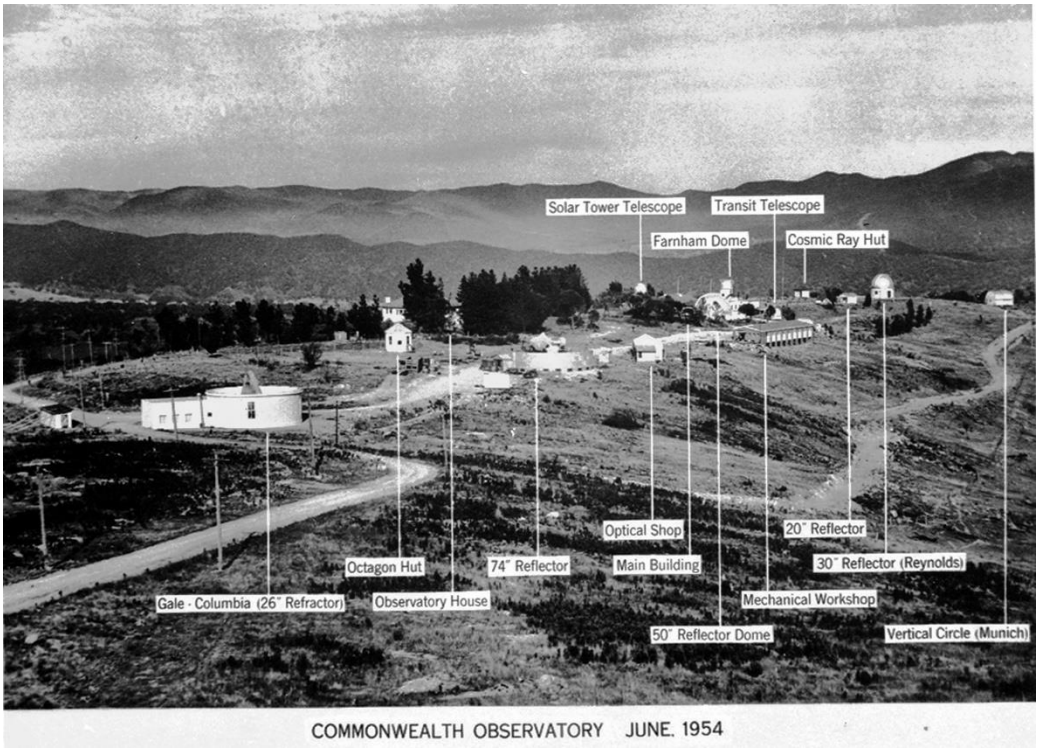
7.2 Nomination Preparation: This nomination was prepared by Keith Baker

7.3 General Notes: Mount Stromlo Observatory has been previously assesses for its cultural heritage values by the Commonwealth under the former Australian Heritage Commission, and the RNE citation subsequently used for its Commonwealth listing under the EPBC Act. It has also been subject to two Conservation Management plans by consultants, so the assessment of cultural values has been taken from those documents where relevant. The previous assessments have been presented with additional information and separately assessed values in the standard format for the Engineering Heritage Recognition Program, thereby giving a further perspective and establishing further significance that had not been fully acknowledged in earlier citations.

Appendix 1. Photographs:

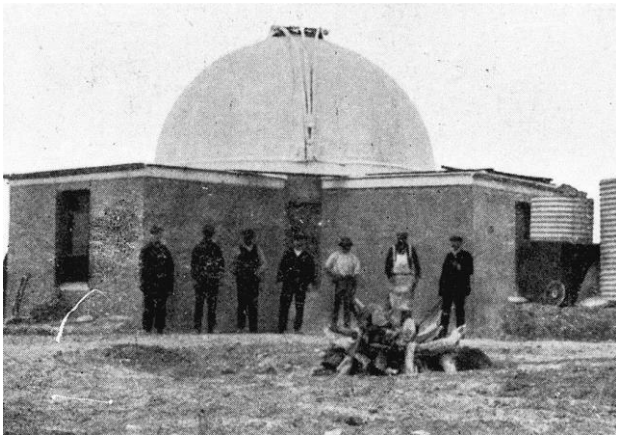
Note all images are from ANU Mount Stromlo Collection unless otherwise noted

(a) Observatory History

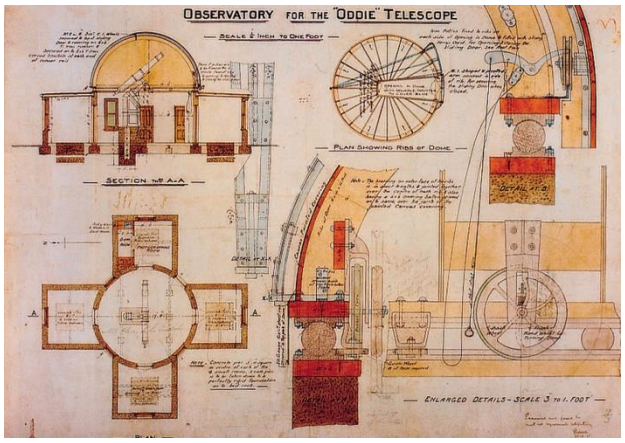


National Library

Comparison of Mount Stromlo Observatory with completion of domes and additional telescopes, October 1961.



Oddie Telescope 1911



Oddie Telescope Observatory Plan 1910

Commonwealth Solar Observatory 1926, showing Farnham Telescope dome

CSO Heliostat completed 1931

Solar Observatory Heliostat basement control room

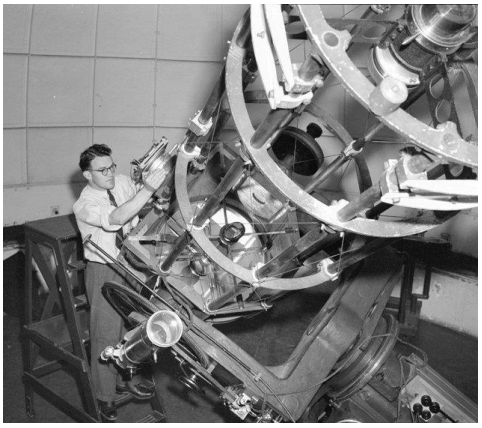
Clabon Allen using the Heliostat
Mt Stromlo Archive

Optical Munitions 1942-45

Kurt Gottlieb with Spectrograph

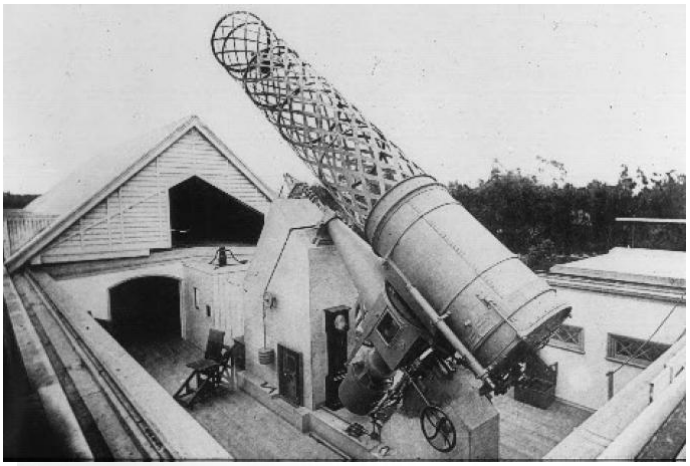
Installing the 74 inch reflector Mirror, 1950s

74 Inch telescope was the largest at Mount Stromlo

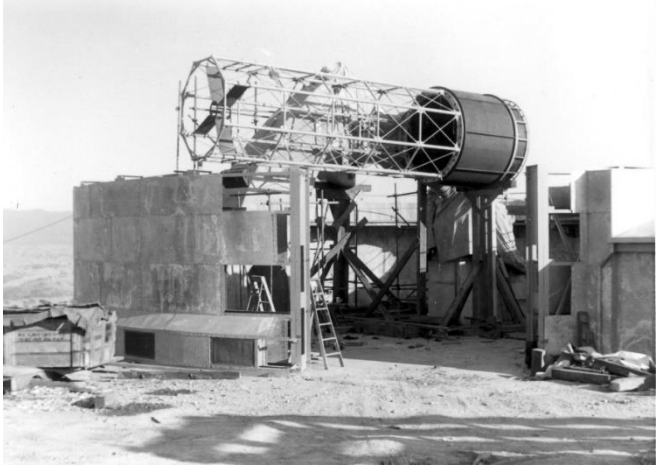


Ben Gascoigne with the 30inch Reynolds telescope 1948 Wikipedia

Commonwealth Time Service 1944-68

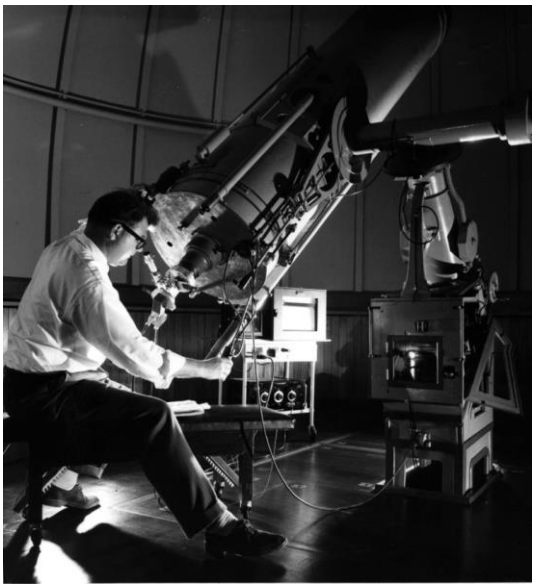


The 1868 Great Melbourne Telescope at Melbourne Observatory prior to 1944



Installing the Great Melbourne Telescope at Mt Stromlo 1950s

After rebuilding as 50 inch at Mt Stromlo



Director Olin Eggen at telescope 1966

50 Inch with camera mounted for Macho Project, 1994

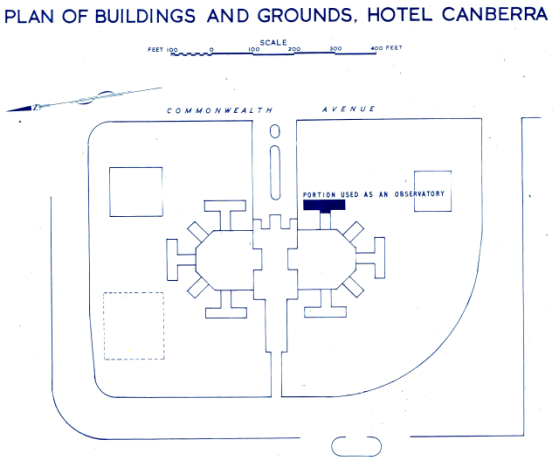
Ruins of 50 Inch telescope, a memory of the destructive 2003 fire K Baker

The Advanced Technology 2.3m Telescope designed and built in the early 1980s at Mt Stromlo

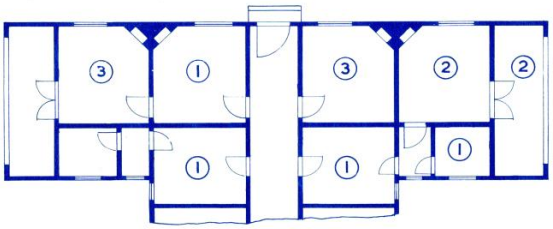
Advanced Technology 2.3m Telescope installed at Siding Spring Observatory

EOS and Geoscience Australia Satellite Laser Ranging Facility K Baker

(b) Workshop History

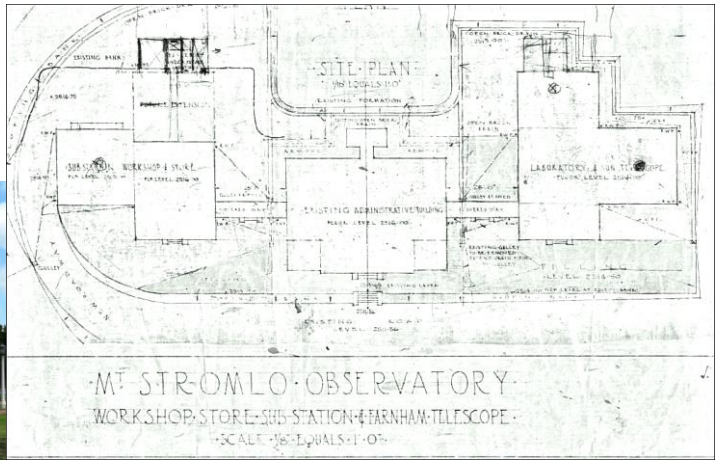


Temporary workshop at Canberra Hotel 1924



Legend
1 Laboratories
2 Workshops & Stores
3 Offices

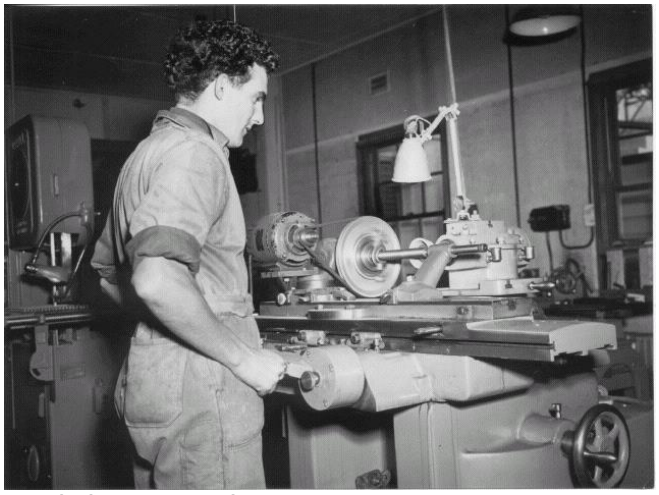
Wing at front of Canberra (Hyatt) Hotel where workshop initially located. K Baker



Plan showing Workshop located within Main Observatory Building 1927

Main Solar Observatory Building 1928 with workshop at rear left

Main Observatory Building with Farnham Telescope and Workshop Wing in foreground. Source: NCA A3560-4416



Workshop around 1945 ANU N Banham collection

Optical Workshop

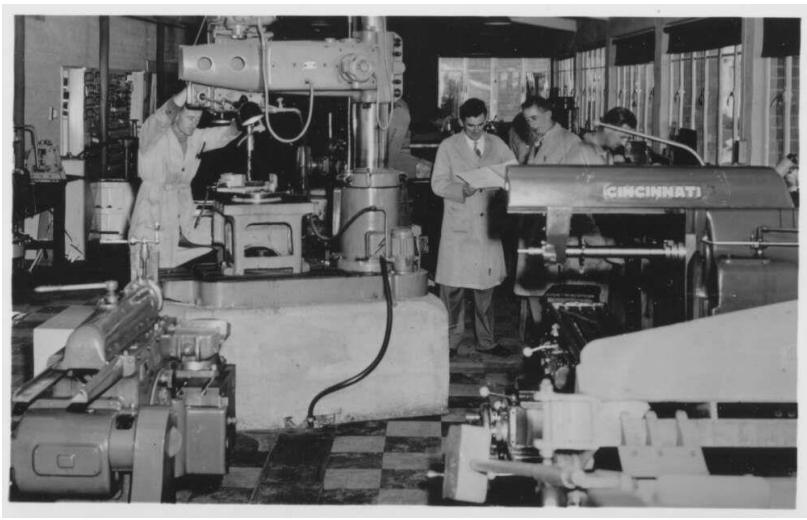
Optical Workshop

No. 9 Mk III Telescope and case, Manufactured at Mount Stromlo, used by long-range heavy artillery units of the Australian army and the RAN for coastal defence installations AWM.

Workshop Foreman Jim Banham in Workshop destroyed in1952 Bushfire

New Workshops under construction 1954 on north western ridge

Mechanical Workshop
ANU Norman Banham Collection,



Mechanical Workshop 1950s National Library

Electronics Workshop 1960s

Electronics Workshop 1977

Mt. Stromlo (1940s) making of lenses for military instruments: lens are mounted on spherical block with pitch and then ground & polished on this revolving wheel. A refugee from enemy occupied country is engaged on this delicate operation and does not show his face for obvious reasons. (negative by E Cranstone). AWM

Optical grinding 1970s?

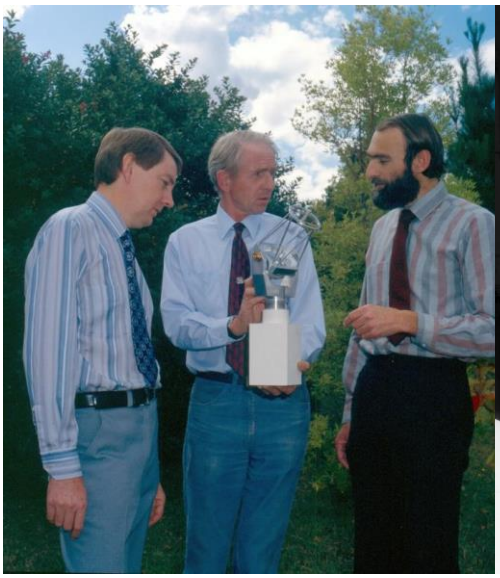
Workshop after destruction by 2003 bushfire

Advanced Instrument Technology Centre 2006

(c) Staff interaction

Director Woolley working with Workshop Foreman Jim Banham

Wehner, Director Bok, Astronomer Hogg, Gottleib and Banham share a drink, 1950s



Hart, Wehner and Hovey

Design and construction team of Advanced Telescope, 1970s

Appendix 2 The Advanced Instrumentation and Technology Centre at Mt Stromlo

The Advanced Instrumentation and Technology Centre (AITC) is a national facility in Canberra. It was established to support the development of the next generation of instruments for astronomy and space science. It is a world-class facility for developing and testing astronomical instrumentation, small satellites, and space payloads and is available for collaborative work with government, industry and other research organisations.

Located within the Mount Stromlo Observatory, it is an integral part of the Australian National University Research School of Astronomy and Astrophysics. AITC is a state of the art facility constructed in two stages following the devastating 2003 bushfire which destroyed the observatory's engineering and optical workshops. The two storey space age facility consists of a large heavily serviced assembly workshop and clean room with overhead cranes, screened rooms, vibration and temperature testing and a vacuum chamber to simulate outer space conditions as well as offices and smaller laboratories for separate research projects.

AITC is now the home for the multi-disciplinary research and development work pioneered by the Mount Stromlo Observatory staff over many years through collaboration between astronomers, engineers, physicists and technologists to advance the capability of observatories worldwide. This work has included and continues to enhance

- Astronomical instrumentation, with particular expertise in optical and infrared spectroscopy, integral-field spectroscopy, and wide-field imaging.
- Adaptive optics, a technology essential to the success of high-resolution observations with the next generation of large ground-based telescopes. Such systems correct for the effects of turbulence in the atmosphere, which causes distortion to the images produced by telescopes on the Earth. They employ laser sensing, high speed real time computing and large numbers of actuators to dynamically change the shape of telescope mirrors to counteract the distortion from turbulence.
- Laser Communications employing technical experience in link acquisition and tracking, adaptive optics, and quantum encryption. By similarly using adaptive optics to correct for atmospheric turbulence, the technology enables high-speed ground-to-ground and ground-to-space laser communications.

Completed projects include

- two instruments for the twin 8m telescopes of the Gemini Observatory in Hawaii, ie the Near-infrared Integral-Field Spectrometer and the Gemini South Adaptive Optics Imager
- instrumentation for the facilities of Mt Stromlo Observatory and Siding Spring Observatory, such as the Dual-Beam Spectrograph and Wide-Field Spectrograph instruments for ANU's 2.3m Telescope (also built largely in house), and the wide-field, 238 megapixel SkyMapper camera.
- The RSAA Telescope Automation and Remote Observing System, a software system that has been designed and implemented to allow the ANU telescopes at a remote location to be operated automatically, or interactively with authenticated control via the internet.

Current projects include

- Adaptive Optics Demonstrator for space debris tracking, through a partnership with Electro Optic Systems
- Development and preparation for flight of a next-generation plasma thruster engine that was invented at ANU

- Giant Magellan Telescope subsystems and instrumentation which will be part of the world's largest and most powerful telescope when it is completed in Chile in 2020. ANU is leading Australia's involvement in the GMT. A team of adaptive-optics and instrumentation engineers and scientists at AITC are designing the laser tomography adaptive optics subsystem which will use high-power lasers to generate artificial 'guide' stars in the sky, where their images can be measured to determine the distortions across a relatively wide area of the sky. A high-speed control loop will then continuously deform the correcting mirrors to reduce the effects of the atmospheric blurring.
- The corrected light collected by the telescope will be fed to back-end instruments that analyse and record the information contained. An Integral-Field Spectrograph will be one of such instruments that is also being designed and built for the GMT by the technical team at AITC.

The expanded facilities at AITC also enable it build and test spacecraft.

- One of these additional facilities is a computer-controlled “shaker” capable of exerting acceleration forces of several tons on various instruments under test. This is vital for anything that is going to be launched into orbit, so that scientists can be confident that it can survive the bumpy ride atop a rocket and still work properly when it arrives in space. It can also be very helpful to be able to test the ability of huge telescope parts to withstand the potentially damaging process of land transport.
- Another facility is a 3m diameter, 4m long thermal vacuum chamber that can not only simulate the airless environment of space, but can also heat or cool a test article assess its performance at extreme temperatures ranging from -170C to +80C. Again this is useful for space projects, but it's also needed to test astronomical instruments and components, many of which are operated in a vacuum.
- The ANU Research School of Astronomy and Astrophysics will reinforce its position at the centre of the national space industry with a new agreement with UNSW Canberra on building and testing satellites and space instruments. The new agreement will boost the role of the AITC as a key national resource for Australia's space industry.

The above summary is based on:

http://rsaa.anu.edu.au/aitc
https://reporter.anu.edu.au/shot-cupid%E2%80%99s-laser
http://rsaa.anu.edu.au/research/highlights/bigger-better-aitc-were-keeping-australia-space-ready

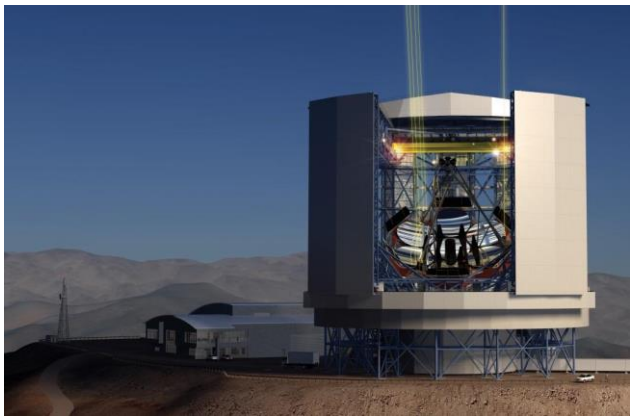
AITC Building at Mount Stromlo K Baker

Integration Hall with cameras tested in space K Baker

Integration Hall ANU RSAA

Vacuum chamber in Integration Hall ANU RSAA

Cube satellite testing ANU RSAA



Design and building Astronomical Instrumentation for Giant Magellan Telescope ANU RSAA

CHANGE CONTROL

VERSION 1	**13 JUNE 2017**	**DRAFT NOMINATION**
VERSION 2	**31 AUGUST 2017**	**REVISED FOLLOWING ANU COMMENT**
VERSION 3	**OCTOBER 2017**	**ADDED ATTACHMENT 2 THE ADVANCED INSTRUMENTATION AND TECHNOLOGY CENTRE AT MT STROMLO**
VERSION 4	**OCTOBER 2017**	**ADDED FURTHER OBSERVATORY PHOTOS AND WORKSHOP PHOTOS**
VERSION 5	**28 OCTOBER 2017**	**TRACK CHANGES ACCEPTED, ADDED NOMINATION LETTER, MINOR REFORMATTING BY OP. NOTE THAT SOME NOTES REMAIN TO BE RESOLVED BY KB.**
VERSION 6	**28 OCTOBER 2017**	**SAME AS V5 BUT WITH NOTES REMOVED.**
VERSION 7	**3 JANUARY 2018**	**DRAFT ENDORSED BY ANU HERITAGE ADVISOR WITH MINOR EDITS ACCEPTED**